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RESEARCH CENTER FOR THE AIRTRON
DIVISION OF LITTON INDUSTRIES

INTERIM DEVELOPMENT REPORT

FOR

AN IMPROVED BROADBAND LOW LOSS TRANSMISSION LINE SYSTEM TO BE INSTALLED WITHIN A RETRACTABLE SUBMARINE MAST

This Report Covers the Period from January 1, 1963 to March 31, 1963

AIRTRON, a division of Litton Industries
Morris Plains, New Jersey

Navy Department Bureau of Ships Electronics Division

Contract No. NObsr-87676

Project Serial No. SS-021001, Task 9025

WRITTEN BY: Robert Q. Maines
Robert Q. Maines
Project Engineer

APPROVED BY:
Dr. Ernest Wantuch
Vice President,
Director of Engineering

DATED: May 31, 1963

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LIST OF ILLUSTRATIONS

ABSTRACT

This report covers the third interim phase of the contract to develop an improved transmission system for use in a submarine mast.

During this period, the ALB-134 ridged waveguide was received from Standard Metals Corporation and the optimum size Splinaline coaxial cable from Precision Tube Corporation.

A 1-in. -radius 90° coaxial bend was fabricated and tested. This bend, in conjunction with a 90° coax-to-ridge waveguide adapter will form the end-fired configuration needed at the top of the mast.

The design of the coupling plate and rail assembly needed for a continuously operating system over a 6 foot range has been completed and parts are being fabricated.

The design of the pressure windows has been completed. A 50 ohm model, which will be used for both bands, has been built, electrically tested and certified by Dusenberry Engineering at 7000 PSI. A graph of VSWR versus frequency is shown.

The 50 to 70 ohm transition has been designed and parts are on hand.

An improved 50 ohm flexible cable has been located which can reduce the loss in the line by 50%.

PURPOSE OF THIS CONTRACT

The development program covered by this report is an extension of work completed at Airtron under Contract Number NObsr-72809, Index Number NE-071200, sponsored by the Electronics Divisions of the Bureau of Ships. The above contract proved the feasibility of replacing the coaxial cable used as transmission lines in the 2.3 to 10.75 Gc/s frequency bands with low-loss, double ridged waveguide transmission lines. The transmission line system developed was installed in the ECM mast of the U.S.S. Hardhead, and proved to be far superior in performance to the standard coaxial cable transmission line system.

The present contract is concerned with developing an improved system suitable for production, with emphasis on the following four areas:

1. Further reduction of insertion loss by at least 1.0 db as a target figure.

2. Reduction in weight without impairing performance.

3. Ease of installation in the submarine.

4. Incorporation of a provision which will permit the antenna to be continuously operable from its uppermost elevated position down to a position 6 feet below that level.

GENERAL FACTUAL DATA

1. Identification of Technicians

This work is being carried on under the general supervision of Dr. Ernest Wantuch, Airtron Vice-President and Director of Engineering.

The following personnel performed work on this contract in the period covered by this report:

A. *Edward S. Hensperger	-	Project Manager	193.5 Hours
B. *Walter D. Wagner	-	Electronics Engineer	190.0 Hours
C. Bernard Donnerstag	-	Mechanical Engineer	416.0 Hours
D. Robert Q. Maines	-	Project Engineer	244.0 Hours

*No longer associated with Airtron.

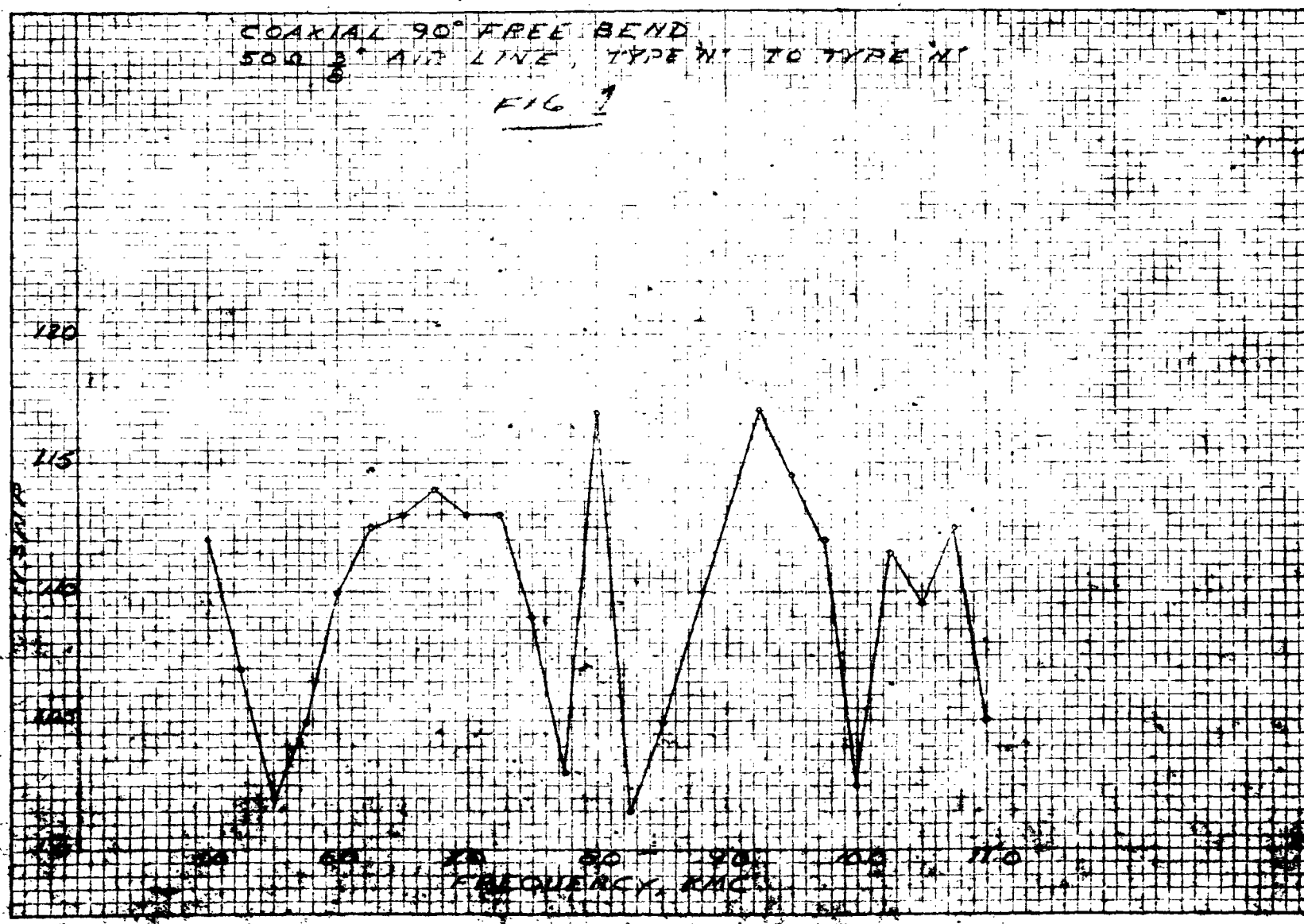
DETAIL FACTUAL DATA

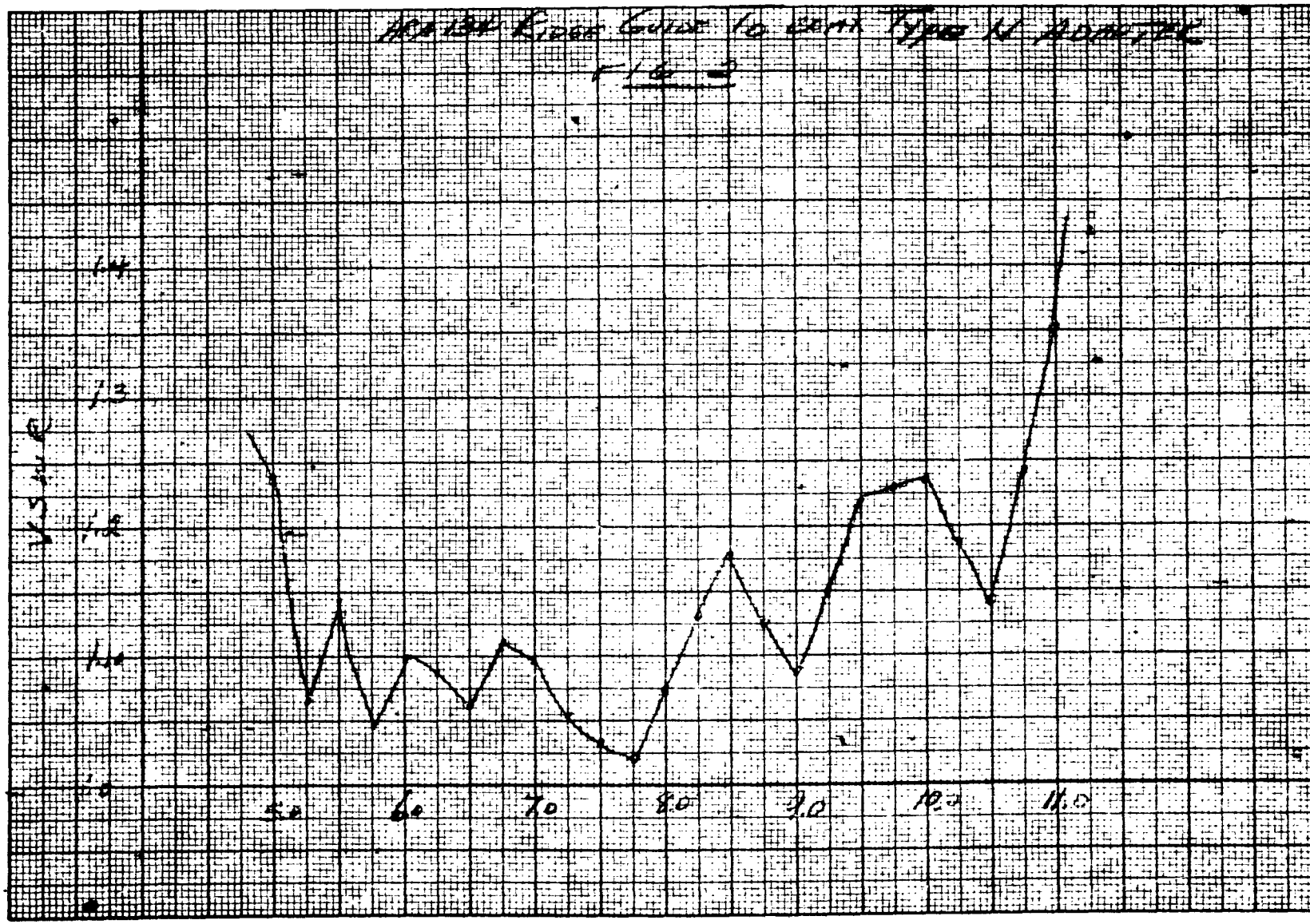
A. COAXIAL-TO-ARA-134 TRANSITION (END-FIRE DESIGN)

As stated in the last report, an end-fire transition was needed at the top of the mast for connection to an antenna. It was decided that the best way to accomplish this would be to connect a 1 in. 90° coax bend to a right angle coax-to-ARA-134 ridgeguide transition. A bend was fabricated and electrically tested, using Type N connectors on both ends. This model yielded a maximum VSWR of 1.17 at 9.25 Gc/s, as shown in Figure (1), which would be less in the final assembly due to the omission of the N-type connector between the bend and the coax-to-ARA-134 transition. The final configuration, which will be one assembly, is now being built. A curve of VSWR versus frequency is also shown for the coax-to-ARA-134 transition in Figure (2).

Figure (3) shows the ARA-134 ridgeguide-to-coax transition. These units are silver plated brass.

Figure (4) shows a high pressure seal, mated with a waveguide-to-coax transition. One of the prime objectives of this development program was to simplify the mechanical assembly of the whole system. As shown in the photograph, the hookup is as straight forward as possible. The seal is slid into the transition and secured with a 1 in. nut. This simple scheme makes removal of the plate from the mast very easy.

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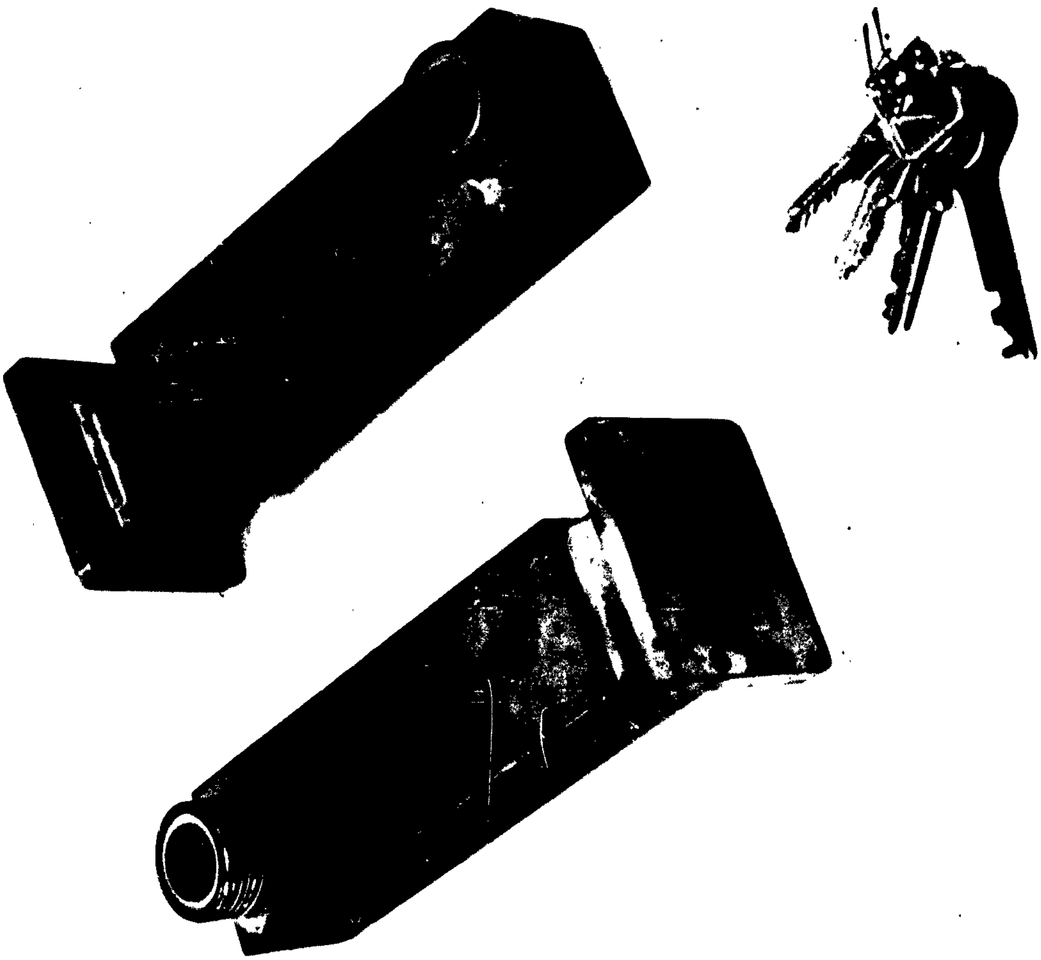


FIGURE 3 - COAX-TO-DOUBLE RIDGE TRANSITION

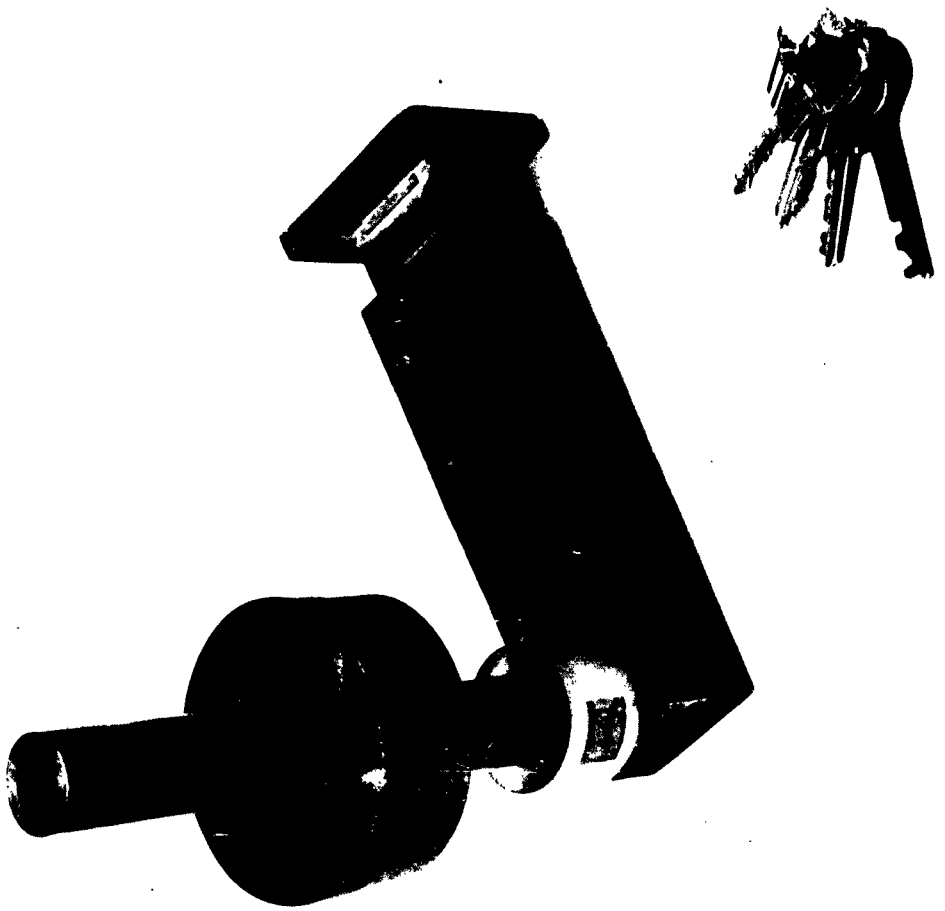


FIGURE 4 - TRANSITION AND PRESSURE SEAL

DETAIL FACTUAL DATA (cont.)

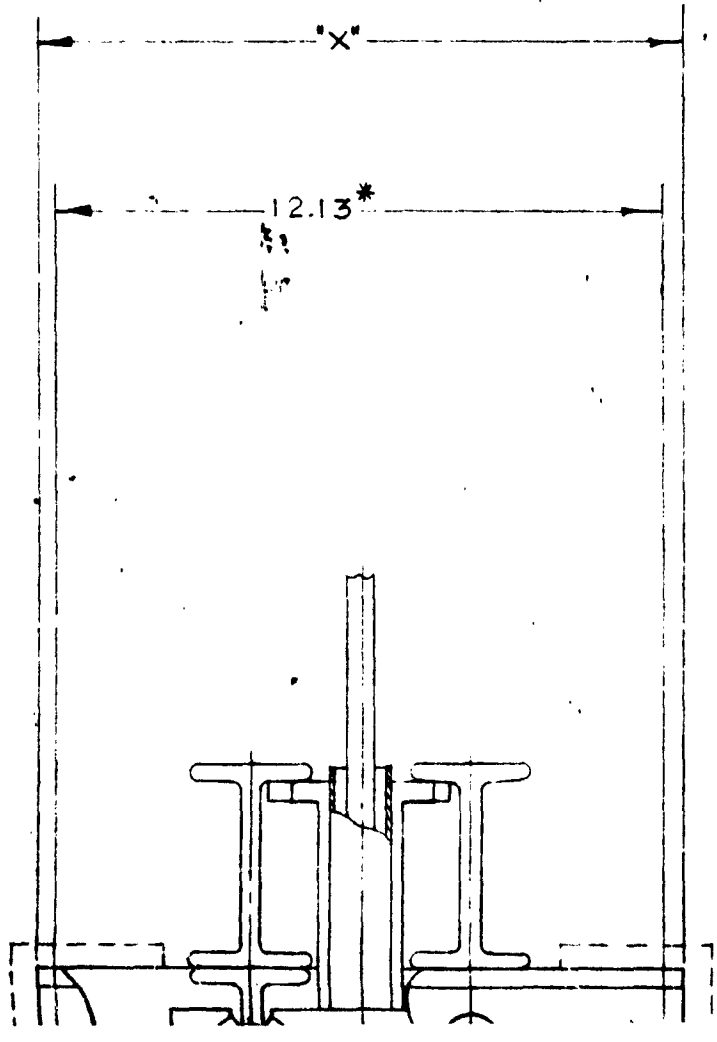
B. COUPLING PLATE AND RAIL ASSEMBLY

The final design of the coupling plate and rail assembly has been completed but there has been some delay in obtaining parts due to a materials problem. The size of the coupling plate is 15-1/4 in. x 12-3/8 in. x 1-3/8 in. and is made from 430 stainless steel. Because of its size, this plate was not readily available as a stock item. As a result, quotations on the machining drawings required two to three weeks for return from vendors. To expedite this procurement, several companies were contacted and prices obtained on forging the plate. The forgings are now being made and upon receipt, will be sent to a vendor for machining. There have not been any difficulties in obtaining vendors for the other parts of the coupling plate or the rail assembly. (Bearings, shafts, etc.) These parts are now being ordered and, as soon as they are received, the complete coupling mechanism will be assembled and life tested.

Figure (5) shows the coupling mechanism and a section of transmission line.

C. 50 TO 70 OHM TRANSITION

The design of these transitions has been completed and parts are on hand, ready for installation into a final line. Being a straightforward



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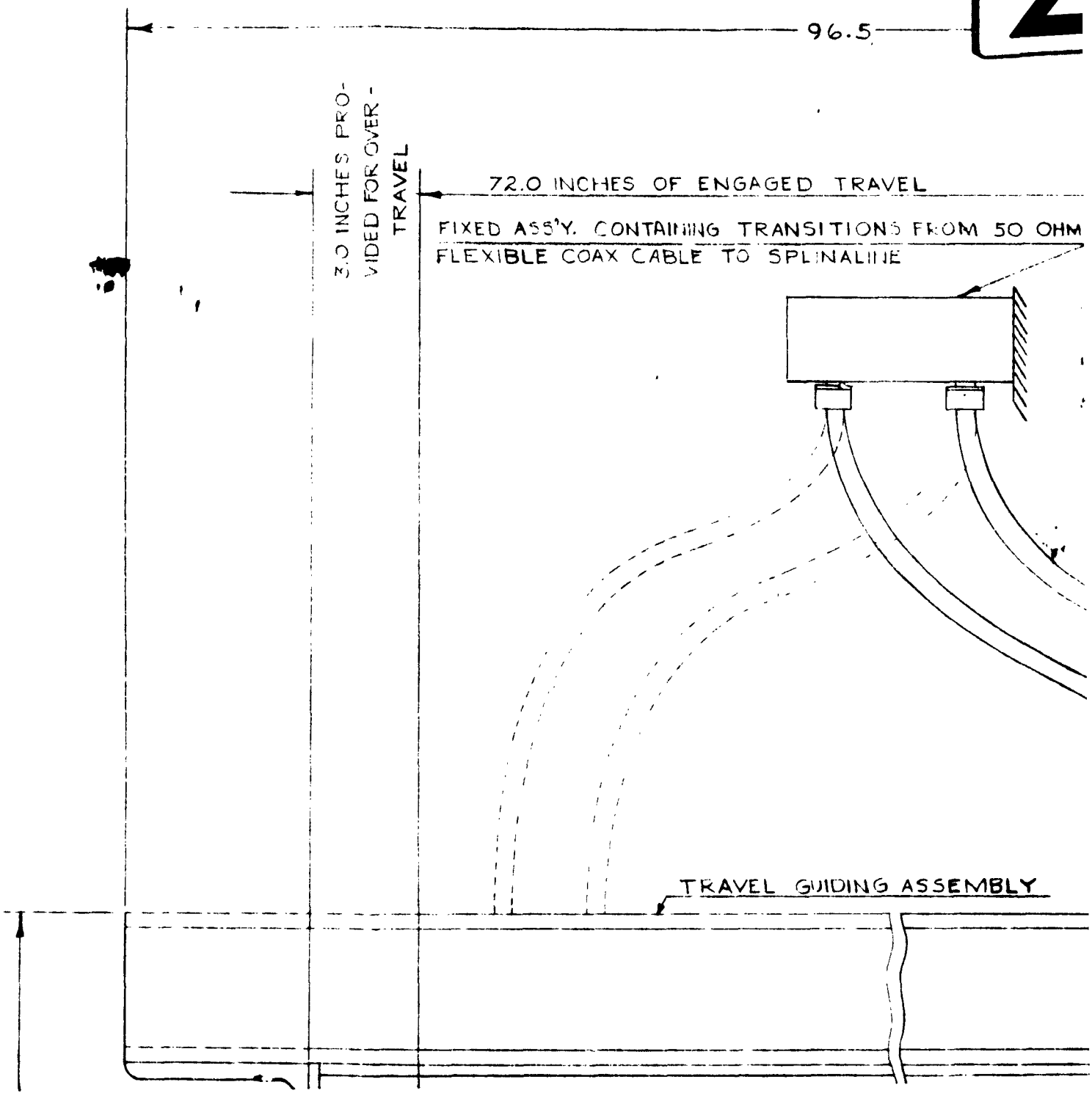
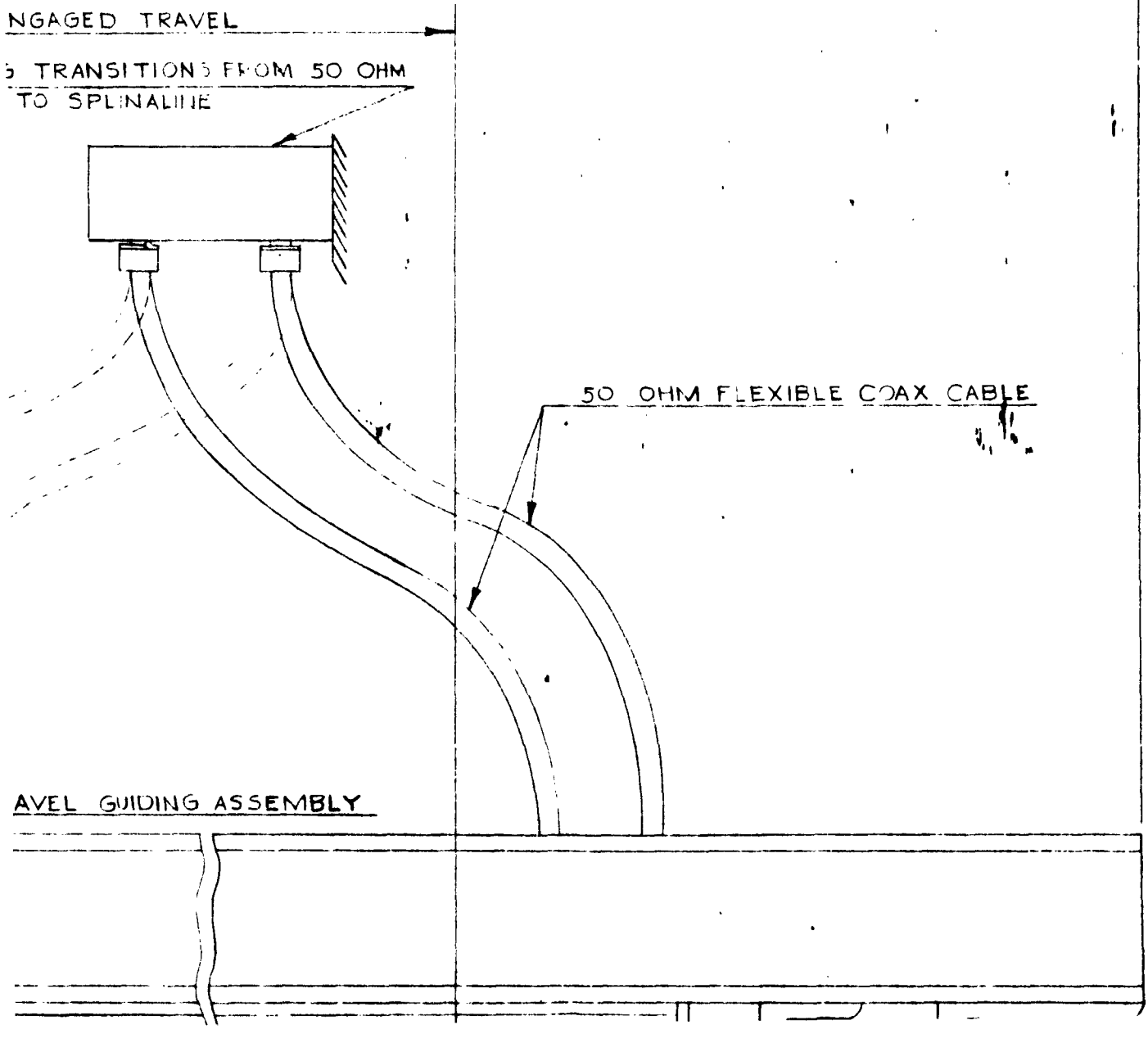

96.5
3.0 INCHES PROVIDED FOR OVER-TRAVEL
72.0 INCHES OF ENGAGED TRAVEL
FIXED ASS'Y. CONTAINING TRANSITIONS FROM 50 OHM FLEXIBLE COAX CABLE TO SPLINALINE
TRAVEL GUIDING ASSEMBLY

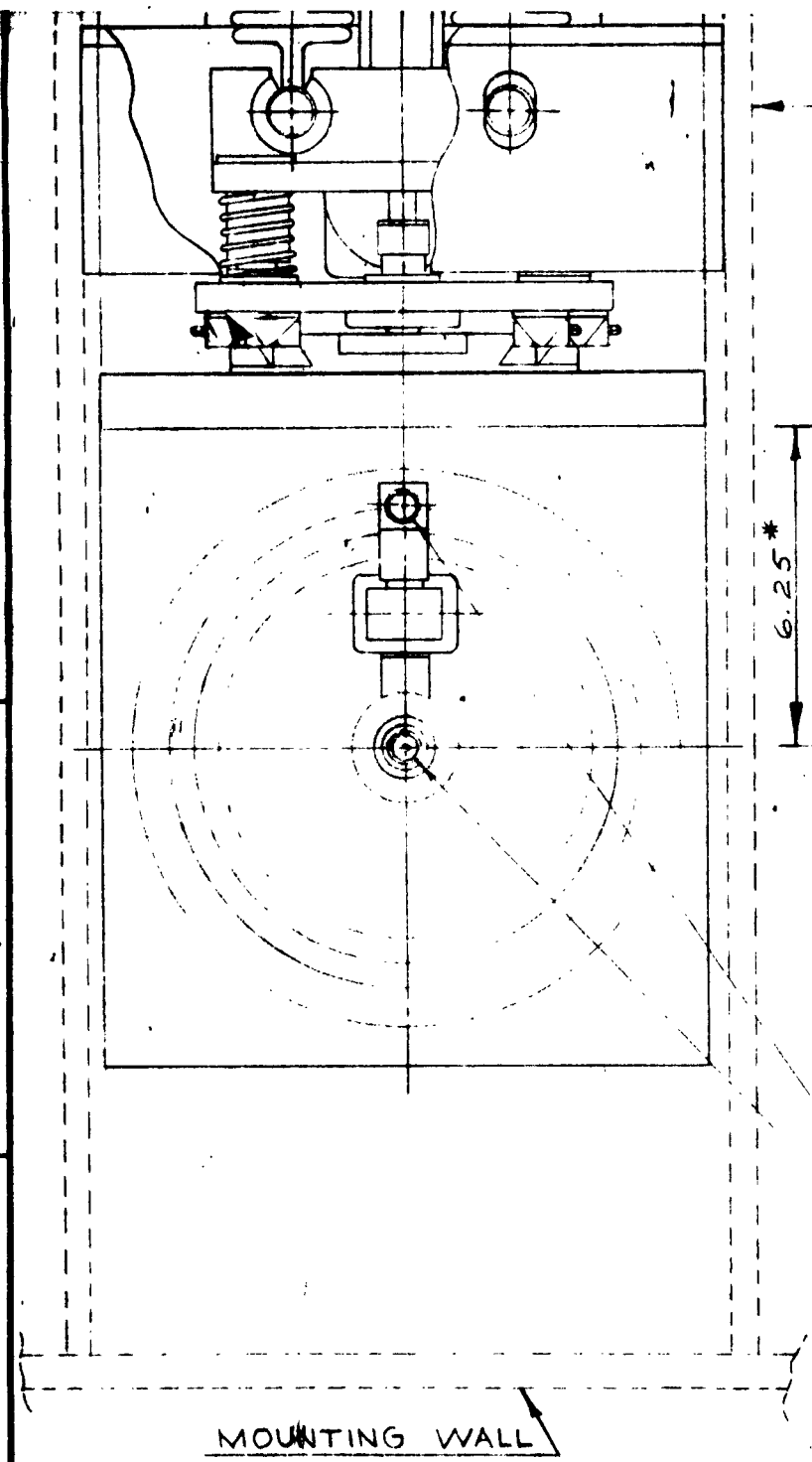
REV.	CHANGE NO.

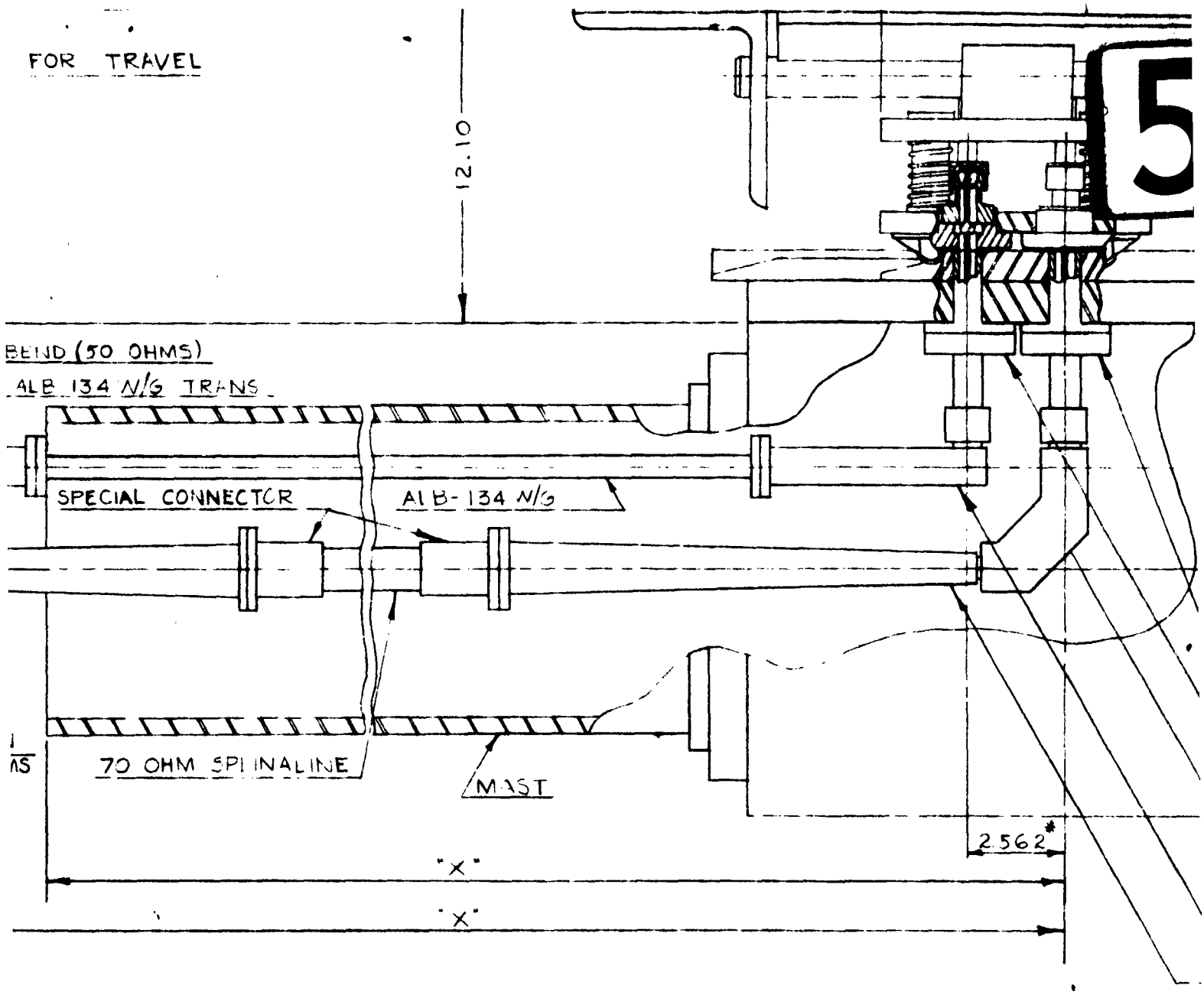
SIZE D | SK-200350 | REV 1 EXP

3

96.5



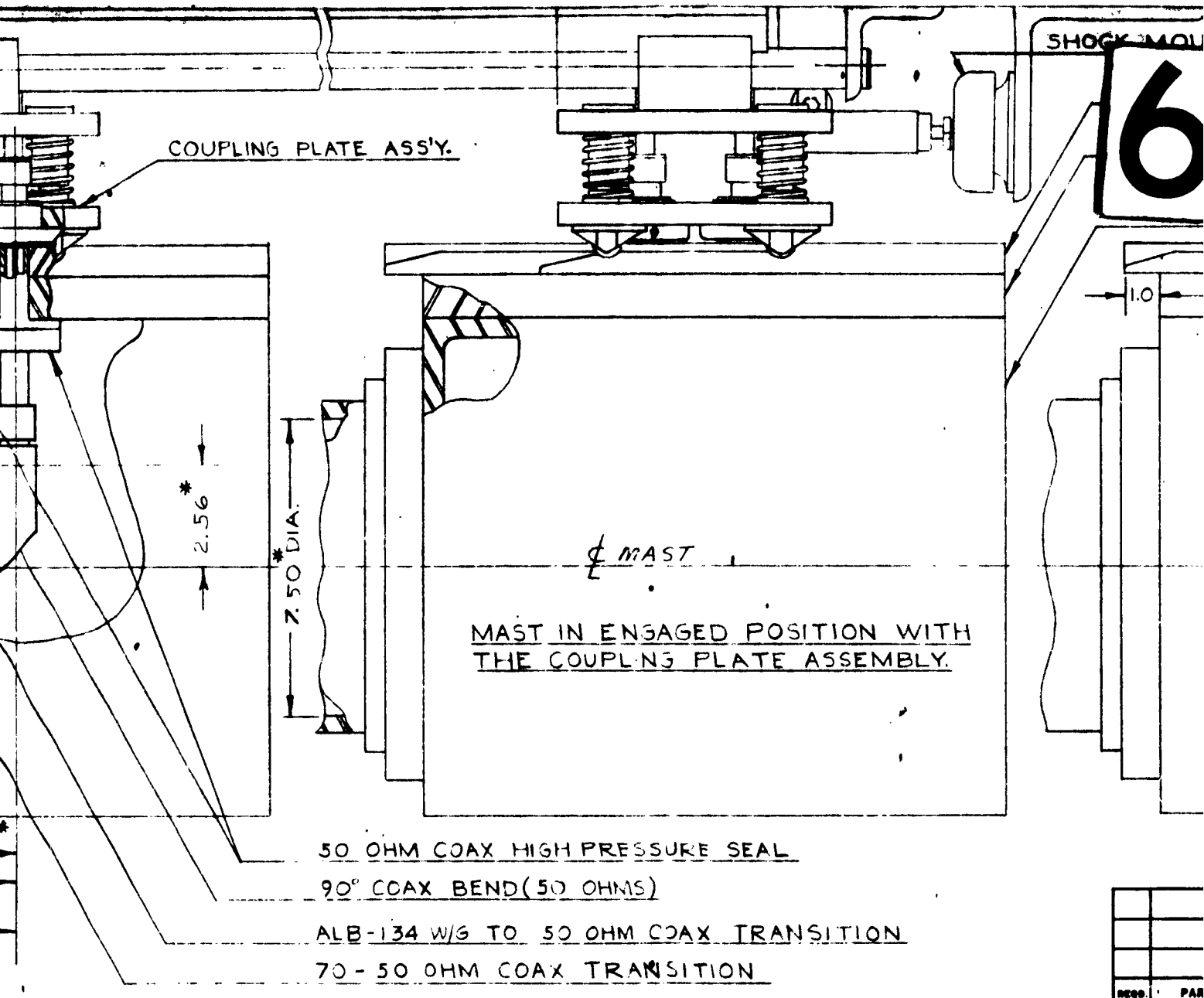

SUPPORT STRUCTURE FOR TRA
GUIDING ASSEMBLY
4
30° COAX BEND (50 OHM
COAX TO ALB 134 N/S
SPECIAL
6.25*
4.56
COAX TRANSITION
50 OHMS-70 OHMS
70 O
TYPE "N" CONNECTOR (FEM
MOUNTING WALL
1. DIM. "X" TO BE ESTABLISHED
2 DIM WITH "*" ASSUMED SAM



NECTOR (FEMALE)

STABLISHED

SSUMED SAME AS PREVIOUS SYSTEM



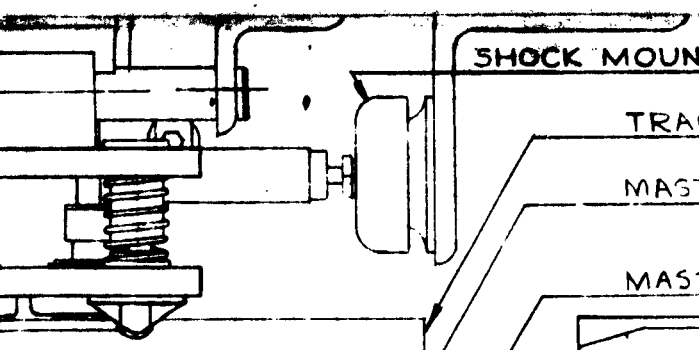
MATERIAL	SPEC.	DRAWN BY B. DONNERSTAG	DATE 3-21-63
TREATMENT		CHECKED BY	
FINISH		ENGINEER B. Donnerstag	3-21-63
CUST. NO.		APPROVED BY	

UNLESS OTHERWISE SPECIFIED ALL MACHINED SURFACES √ BREAK ALL INTERNAL AND EXTERNAL SHARP CORNERS .005 TO .015 RADIUS.

UNLESS OTHERWISE SPECIFIED [redacted] DRILL HOLE TOLERANCES AS SPECIFIED

THREADS TO BE IN ACCORD WITH U. S. DEPT. OF COMMERCE "SCREW THREAD STANDARDS FOR FEDERAL SERVICES" 1960 SUPL. TO HANDBOOK H-28

REF. S.O. 524801	NEXT ASSEM.	FIN. ASSEM.	SCALE



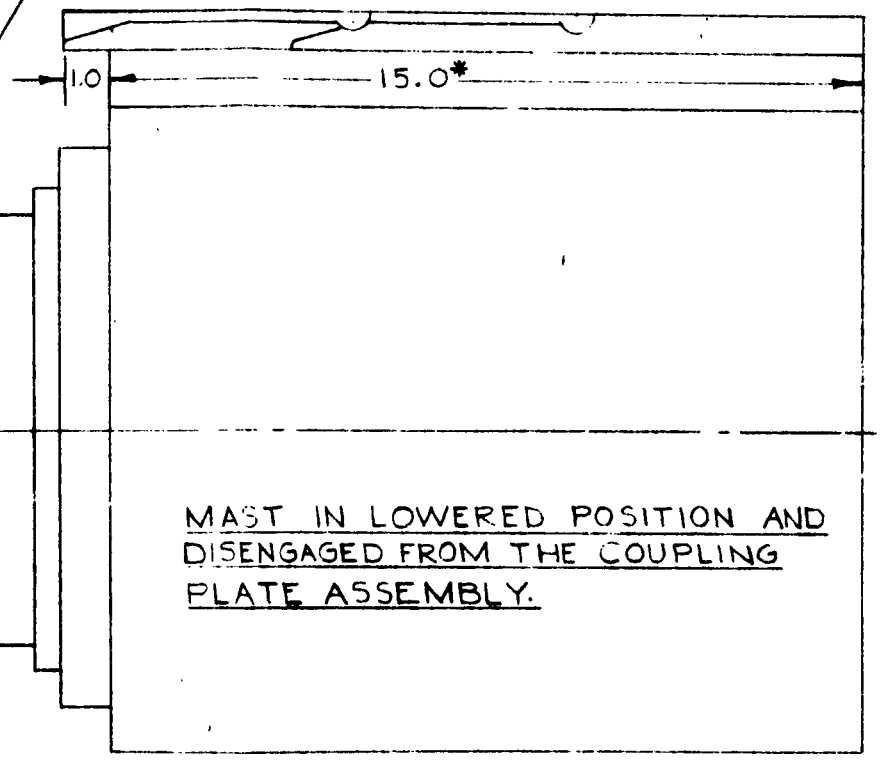
SHOCK MOUNT

TRACK PLATE

MAST BASE SEALING PLATE

MAST BASE HOUSING

7



D SK-200350 1 EXP.

T

GED POSITION WITH
PLATE ASSEMBLY.

MAST IN LOWERED POSITION AND
DISENGAGED FROM THE COUPLING
PLATE ASSEMBLY.

URE SEAL

AX TRANSITION

ITION

REQD.	PART NUMBER	NOMENCLATURE

	SPEC.	DRAWN BY B. DONNERSTAG	DATE 3-21-63
		CHECKED BY	
		ENGINEER B. Donnerstag	3-21-63
		APPROVED BY	

UNLESS OTHERWISE SPECIFIED
[redacted]
ANGULAR [redacted]
DRILL HOLE TOLERANCES AS SPECIFIED

THREADS TO BE IN ACCORD WITH U. S. DEPT. OF COMMERCE "SCREW THREAD STANDARDS FOR FEDERAL SERVICES" 1956 SUPL. TO HANDBOOK H-28

NEXT ASSEM. | FIN. ASSEM.

INSTALLATION LAYOUT E.C.M. TRANS LINE

SCALE 1" = 3" | UNIT WEIGHT

AIRTRON
A DIVISION OF LITTON INDUSTRIES
MORRIS PLAINS
LINDEN LOS ANGELES

SIZE D | SK-200350 | REV. 1 EXP.

C. 50 TO 70 OHM TRANSITION (cont.)

linear taper which has been used with success many times before, a separate electrical check of each unit should not be needed. These transitions will be checked in the final line in conjunction with other components. Figure (6) shows the complete 50 to 70 ohm transitions consisting of inner and outer conductors, shown in the center, and the mating hardware for joining the Splinaline cable. The outer conductor of the transitions are copper electroforms, machined to finished dimensions. The inner conductors are tapers, machined from drill rod.

The threaded couplings for the Splinaline cable, shown on the left and right of the photograph, are fabricated from brass, with "O" ring grooves for moisture sealing. A model using the actual cable with a coupling attached, withstood a 3000 pound pull test without separating.

D. PRESSURE WINDOWS

Due to the high loss encountered in the previous coax seals, a new 50 ohm pressure window has been designed. The new seal is a straightforward, 50 ohm coax line using Stycast 0.0005 as the dielectric. This dielectric has excellent shock characteristics along with low loss and low porosity. A prototype unit was fabricated using beryllium copper, Stycast 0.0005 and a bonding agent to cement the Stycast to the

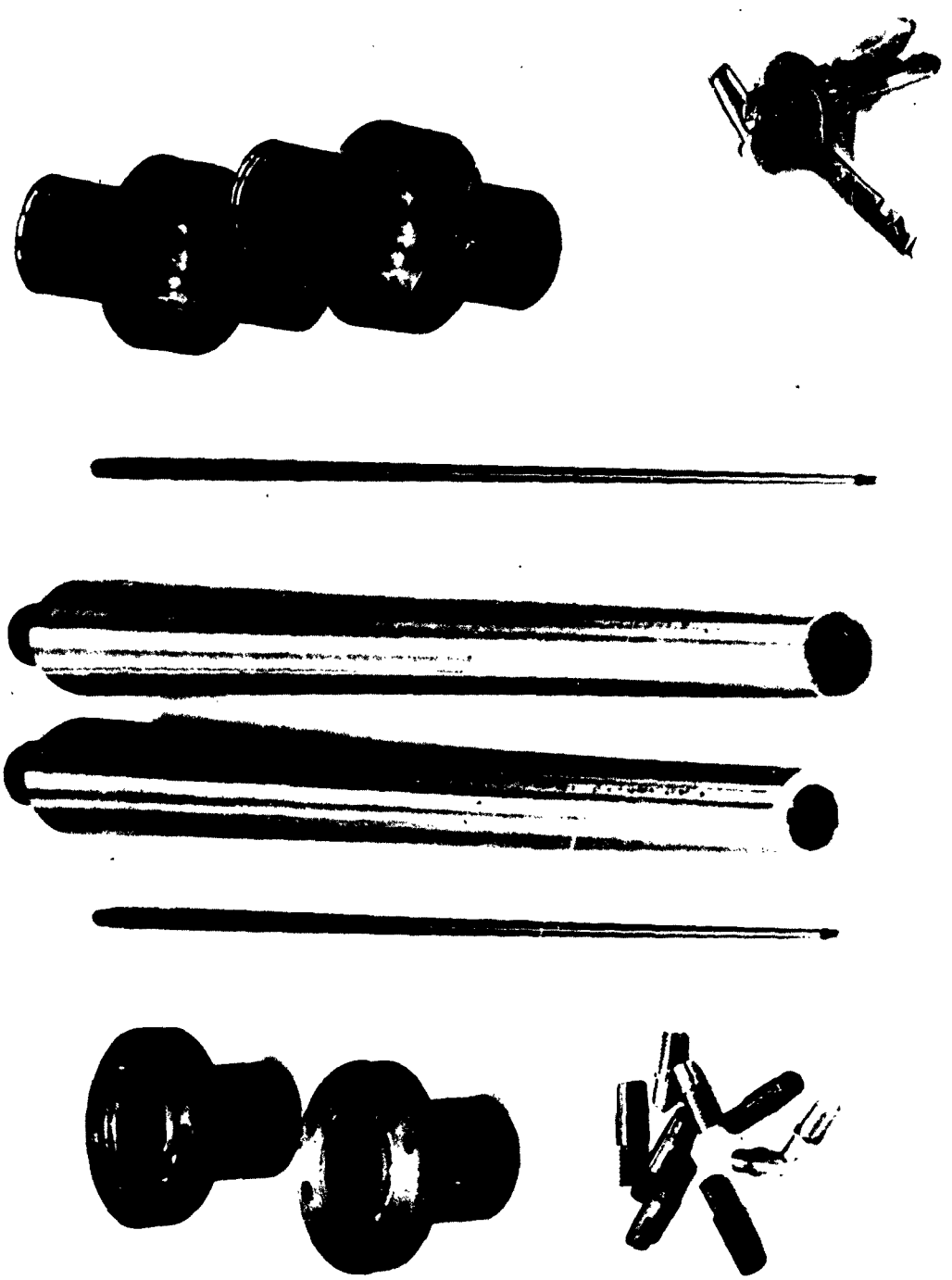


FIGURE 6 - DETAILS OF 50-TO-70 OHM TRANSITIONS

D. PRESSURE WINDOWS (cont.)

beryllium copper. This bonding agent (Eccobond 45) was supplied by Emerson and Cummings, who also furnished the Stycast. An electrical check from 2 to 11 Kmc/s showed the highest VSWR was 1.22 at 9600 Mc/s and the loss at 11 Kmc/s was 0.1 db. Figure (2) shows a graph of VSWR versus frequency. The unit was subjected to a successful static test of 7000 PSI. The test was performed at Dusenberry Engineering, which is a government-qualified source. Final units are now being made and they will be checked in the system.

Figure (7) shows three views of the pressure seal. The lower right view is a complete high pressure seal, ready for connection to the mast plate and transmission line. The lower left view shows the seal opened up to expose the Stycast 0.0005 dielectric. At this point, the dielectric had not been cemented to the outer conductor. The different shades of the two halves is caused by different metals. The side that is connected to the mast plate, and makes contact with the coupling plate, is beryllium copper. The opposite side, that contains the 1-in. nut, is made of brass.

In the upper portion of the picture is shown the prototype seal, which was subjected to the 7000 PSI static pressure test, and the mating piece which will be connected to the coupling. These two pieces will form the make and break surface. This model was used to test the VSWR across the band, (2-11 Kmc/s), which is plotted in Figure (8).

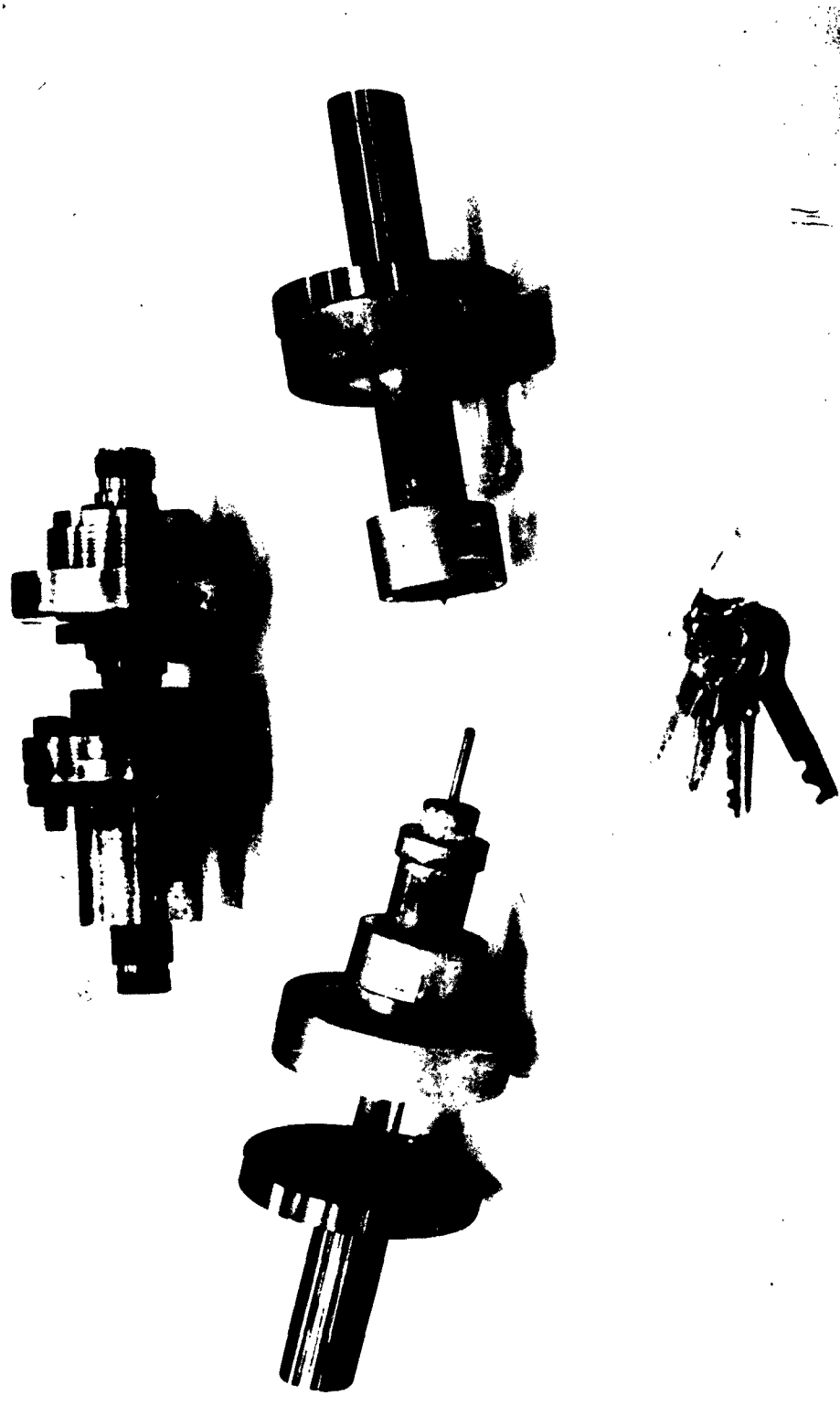
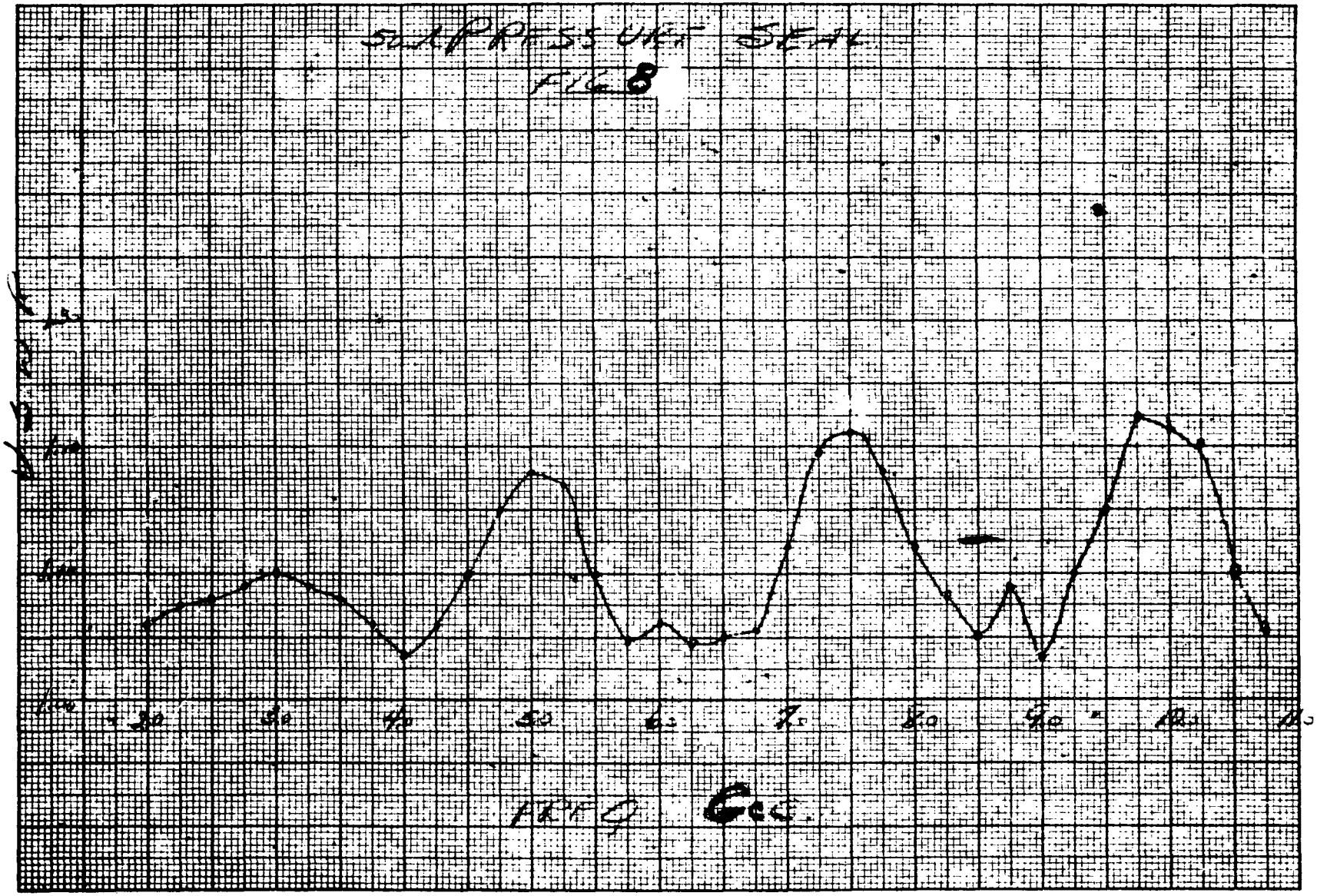


FIGURE 7 - THREE VIEWS OF PRESSURE SEAL



E. 50 OHM FLEXIBLE CABLE

In search of a flexible cable to connect the moving mast to a fixed point, Times Wire and Cable Company, Wallingford, Connecticut was contacted. They have stated that they can supply us with a 50 ohm cable with good flexibility, along with 50% less loss than RG9.

As stated in the last report, a four foot section of RG9 would contribute 2.0 db loss at 10 Kmc/s. A comparable length from Times Wire would have a 1.0 db loss at 10 Kmc/s. These new cables are being investigated and will be elaborated on in the next report.

PROGRAM FOR THE NEXT PERIOD

A. Obtain the hardware needed for the complete coupling plate, rail assembly and transmission lines.

B. Start life testing of coupling plate.

C. Assemble complete upper and lower transmission lines.